Greenhouse Gas Emissions in Washington State:

Sources and Trends

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Importance of Energy Use

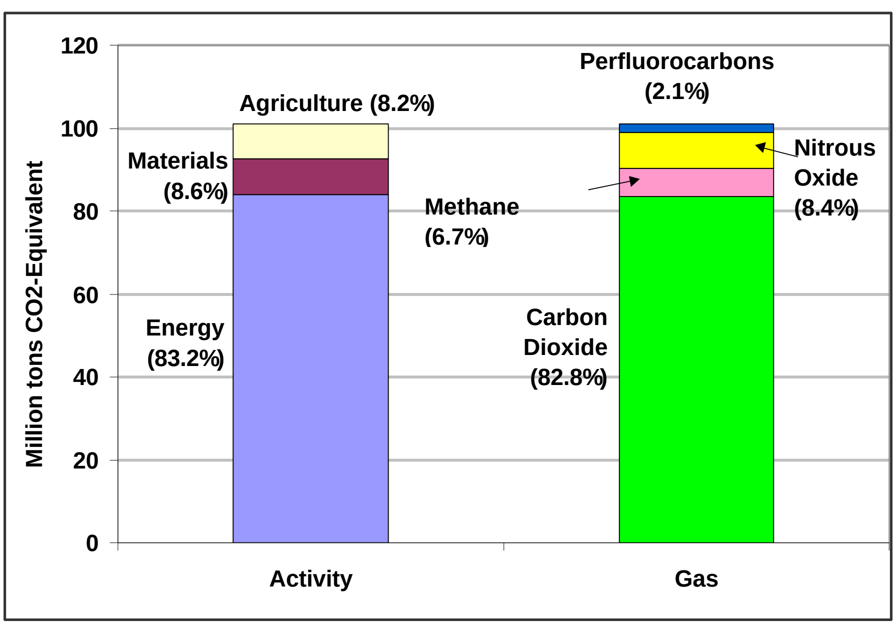
Greenhouse gases are emitted by human activity. Dividing human activity into three categories is useful to understand the problem of greenhouse gas emissions and describe solutions:

- Energy
- Materials
- Agriculture

Energy activity releases greenhouse gases when fossil fuels are burned to supply our energy demands. These activities range from burning natural gas to produce electricity to consuming gasoline to power our cars, trucks, and buses. Material activity releases greenhouse gases when we produce or dispose of materials. Emissions from material activity include methane emissions from decomposition of organic waste in landfills, carbon dioxide (CO_2) emissions from cement production, and perfluorocarbons (PFC) emissions from aluminum production. Agricultural activity produces nitrous oxide (N_2O) from manure and fertilizer use, and methane (CH_4) from animal metabolism and manure decomposition.

Figure 1 shows 1995 emissions of greenhouse gases by activity and type of gas. Energy use is obviously the dominant activity, and carbon dioxide the dominant greenhouse gas. Total emissions in 1995 were 101 million tons CO_2-equivalent.[i] The rest of this paper will only deal with energy-related emissions.

Figure 1. Greenhouse Gas Emissions, Washington State, 1995



History of Energy-Related Carbon Dioxide Emissions

Figures 2 and 3 show carbon dioxide emissions from the buildings, industrial, and transportation energy use sectors from 1960 to 1995. The building sector includes residential and commercial uses of energy. Emissions from electricity production are assigned to the end-use sector in proportion to their use of electricity.[ii] The industrial sector has been relatively constant during the last 35 years, increasing only 51 percent, compared to the building and transportation sector increases of 120 percent and 247 percent, respectively. Population during the period increased 87 percent.

Figure 2. Carbon Dioxide Emissions by Energy Sector, Washington State

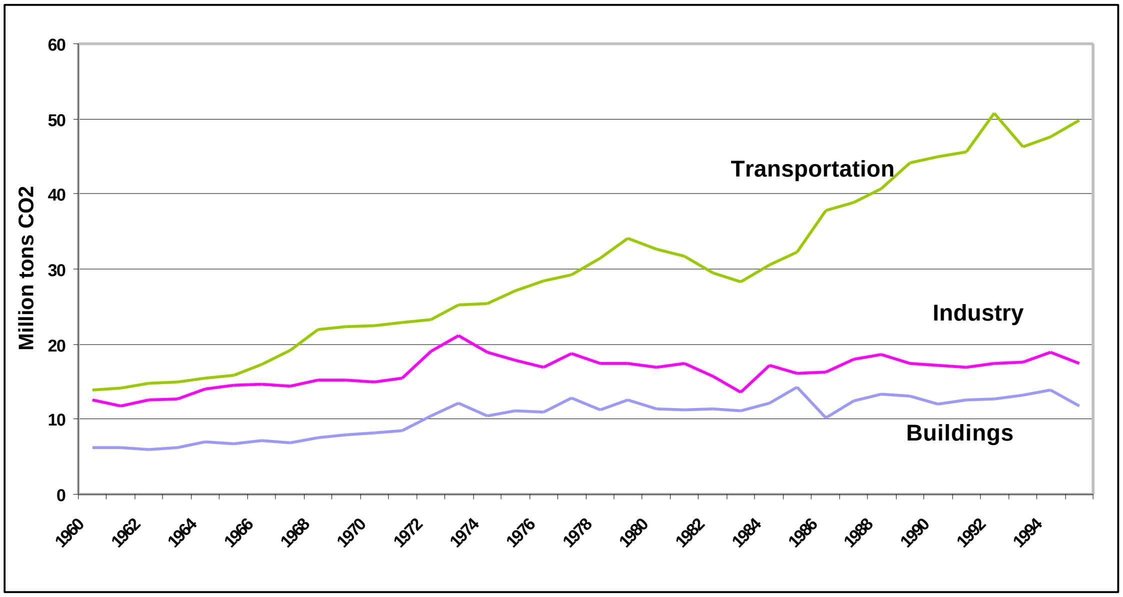
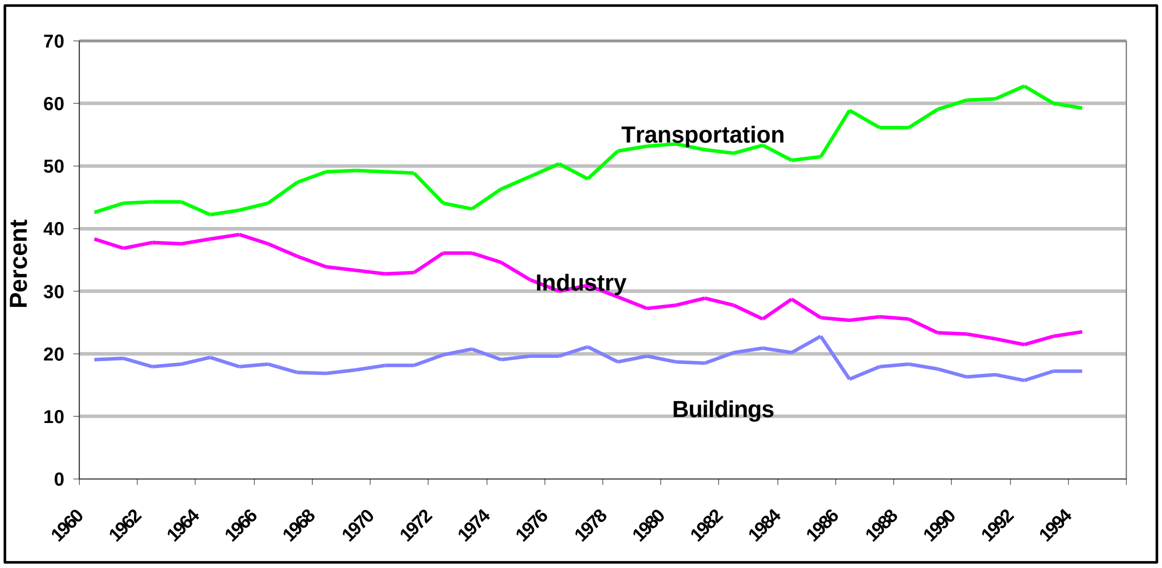


Figure 3 shows the percentage contribution of each end-use sector over time. The industrial sector's share has declined, while building sector contributions have been relatively constant at 20 percent of carbon dioxide emissions. Transportation increased from 43 to 63 percent of total emissions between 1960 and 1995.

Figure 3. Carbon Dioxide Emissions Percentage by Energy Sector, Washington State



Factors driving emissions

One way to view factors contributing to carbon dioxide emissions is by a simple multiplication of three variables: energy use per person, carbon dioxide emissions per unit of energy use, and population. In a mathematical formula, the relationship looks like this:

$$CO2Emissions = \frac{Btu}{capita}\ x\ \frac{CO2}{Btu}\ x\ Population$$

The Btu/capita factor relates to energy efficiency, or energy use per person used to meet our energy demands. The CO_2/Btu factor shows the amount of carbon dioxide emissions for each unit of energy provided. The type of fuel used determines the magnitude of the carbon dioxide intensity factor. For example, carbon dioxide emissions in pounds per million Btu of fuel consumed are 200 for coal, 118 for natural gas, and zero for hydroelectric.

Table 1 shows how the 10-year average of these factors has changed since 1960. Energy intensity is largely driven by economic conditions in the state. Energy use per capita declined in the 1980s due to the recession in the early years of the decade. Part of the reduction was also due to economic sectors, such as industry, becoming more energy efficient. Carbon dioxide intensities have been surprisingly constant, considering the introduction of a new coal-fired power plant in the early 1970s. However, about 35 percent of Washington's energy supply comes from zero-carbon dioxide-emitting hydroelectric, nuclear, and biomass resources. While energy and carbon dioxide intensities have been relatively constant, population has increased steadily. This has resulted in a continuous increase in total carbon dioxide emissions.

Comparing per capita emissions gives some perspective on overall carbon dioxide emissions. Washington's emissions are approximately 15 tons of carbon dioxide per person. The United States average is 22 tons per capita, while the global average is four tons per capita.

Table 1. Energy Drivers of Greenhouse Gas Emissions

Decade	Energy Intensity, Million Btu Per Capita	CO2 Intensity, Tons Carbon Dioxide per Million Btu	Population In Millions	Emissions, Million Tons Carbon Dioxide
1960-69	242	0.051	3.0	37.5
1970-79	305	0.050	3.6	55.6
1980-89	281	0.051	4.4	63.4
1990-95	281	0.054	5.1	77.5

Projected Emissions

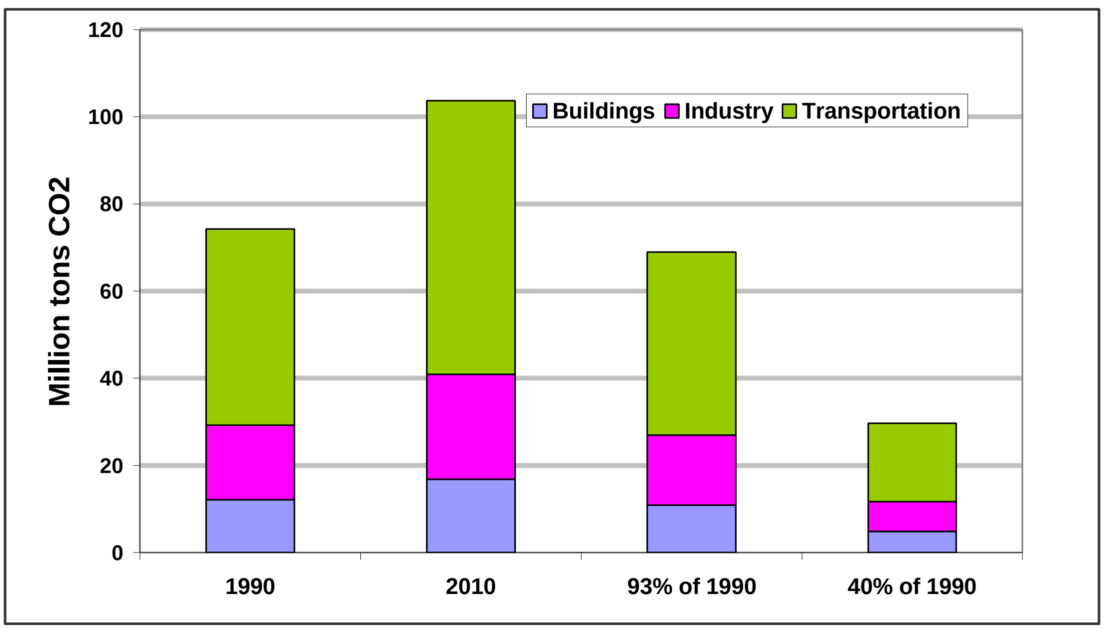
Projecting future events is a very uncertain exercise. For illustration purposes, we assume that energy and carbon dioxide intensities will remain constant during the next few decades, and that emissions will be driven only by population increase, projected at 40 percent between 1990 and 2010.[iii] Each sector is also assumed to maintain its same proportion of total emissions. Actual emissions are likely to be quite different because of changes in technology and energy use patterns. For example, large-scale adoption of fuel cell vehicles would decrease emissions while more vehicle miles traveled per person would increase emissions.

Figure 4 shows 1990 emissions, projected emissions for 2010, a seven percent reduction of 1990 levels to meet the Kyoto Protocol, and a 60 percent reduction of 1990 levels that are considered by scientists as necessary to stabilize greenhouse gas concentrations. To reduce projected 2010 emissions to 93 percent and 40 percent of 1990 levels, requires absolute reductions of 34.7 and 74.0 million tons of carbon dioxide, respectively.

Carbon dioxide emissions from energy-related activities could be reduced by increasing energy efficiency and by using non-fossil sources of energy. Energy intensity decreased eight percent from the 1970s to the 1980s. New energy efficiency technology is available and used. This new technology has resulted in constant energy intensity since 1980. However, the energy intensity, Btu/person, must decline to compensate for population increases. This requires new energy efficient technology and greater adoption of this technology by the marketplace.

The other option to reducing emissions is to use fuels that emit less carbon dioxide per unit of energy provided. Use of renewable energy sources, such as hydroelectricity, photovoltaic electricity, biomass and geothermal, all result in lower carbon dioxide emissions. As with energy efficiency, new technology, lower costs, and adoption by the marketplace are necessary if carbon dioxide emissions are going to be reduced.

Figure 4. Projected Carbon Emissions to 2010, Washington State



Reducing Energy Related Greenhouse Gas Emissions

Any energy production or use that depends on the combustion of fossil fuels will produce greenhouse gases. Consequently, actions that either reduce the amount of energy use or improve the efficiency of energy use or production, result in greenhouse gas reductions. There are hundreds, if not thousands, of possible methods to either reduce energy use or improve energy efficiency in Washington State. Here are two examples that depict the magnitude of reductions.

- **Increase the fuel efficiency of automobiles.**

  As figure 2 illustrated, transportation energy use is both the largest greenhouse gas producer and the fastest growing sector. Carbon dioxide emissions in the year 2010 from light duty vehicles could be reduced by 7.3 million tons, or 24 percent, if average vehicle efficiency increased from the projected level of 20.3 to 26.7 miles per gallon.[iv]

- **Increase the efficiency of electricity use in buildings.**

  The Northwest Power Planning Council estimates that there are approximately 13 million megawatts of cost-effective electricity savings available in the Northwest.[v] About 60 percent of that is in Washington State. Even given our very low CO2 production ratio because of hydro, nuclear, and biomass facilities, those savings would reduce annual greenhouse gas emissions by 1.5 million tons/year.

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[i] Carbon dioxide equivalents are used because different greenhouse gases have different global warming potentials. In other words, some gases are more potent than others. Converting emissions to a carbon dioxide equivalent permits calculating the total contribution of different greenhouse gases and comparing their relative contributions to global climate change. The equivalency is based on the same greenhouse effect of carbon dioxide emissions. For example, one pound of methane emissions has the same greenhouse effect as 21 pounds of carbon dioxide.

[ii] Carbon dioxide emissions from electricity consumption were calculated based on total electrical generation and total carbon dioxide emissions from electric generators within Washington State. For 1995, emissions were 0.11 tons CO_2/MWh. The average emissions for the combined Northwest states of Idaho, Montana, Oregon, and Washington were 0.18 tons CO_2/MWh, while emissions from all states in the Northwest Power Pool (adding Wyoming, Nevada, and Utah) were 0.52 tons CO_2/MWh. Electricity consumption within Washington may be responsible for higher carbon dioxide emissions in other states. For this report, only emissions directly produced in Washington were included.

[iii] Washington's 1990 population was 4.867 million, which is expected to grow to 6.8 million by 2010, according to the Washington State Office of Financial Management. See http://www.wa.gov/ofm/ for more information.

[iv] Fuel efficiency projections from Alliance to Save Energy, Energy Innovations, 1997 and vehicle miles traveled from Washington State Department of Transportation.

[v] Northwest Power Planning Council, Northwest Power In Transition: Opportunities and Risks – Draft Fourth Northwest Conservation and Electric Power Plan, 96-5, March 1996.